The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A photoelectric encoder comprising:

a main scale with a grating;

a light receiving portion with an index grating pattern and a light receiving element, the light receiving portion capable of moving relative to the main scale, the light receiving portion detecting a bright/dark pattern obtained at least by the grating of the main scale; and

a lens disposed between the main scale and the light receiving portion,

wherein a magnification of an image is set by adjusting distances among the lens, the main scale, and the light receiving portion.

2. The photoelectric encoder according to Claim 1, wherein the light receiving portion is a light receiving element array in which the index grating pattern and the light receiving portion are integrated with each other.

3. The photoelectric encoder according to Claim 1, further comprising an aperture disposed at a position of a focal point of the lens.

4. The photoelectric encoder according to Claim 1,wherein the lens is a lens array.

5. The photoelectric encoder according to Claim 4, further comprising an aperture array disposed at a position of a focal point of the lens array.

6. The photoelectric encoder according to Claim 4, further comprising a partition plate disposed between adjacent lenses of the lens array.

7. The photoelectric encoder according to Claim 1 wherein the main scale is of a reflection-type.

8. The photoelectric encoder according to Claim 7 further comprising a diffused light source, wherein the lens serves also as a collimator lens.

9. A photoelectric encoder comprising:

a main scale with a grating;

a light receiving portion with an index grating pattern and a light receiving element, the light receiving portion capable of moving relative to the main scale, the light receiving portion detecting a bright/dark pattern obtained at least by the grating of the main scale; and

an aperture disposed between the main scale and the light receiving portion,

wherein a magnification of an image is set by adjusting distances among the aperture, the main scale, and the light receiving portion.

10. The photoelectric encoder according to Claim 9, wherein the light receiving portion is a light receiving element array in which the index grating pattern and the light receiving portion are integrated with each other.

11. A device for measuring the relative displacement between two members, the device comprising:

(a) a scale grating extending along a measuring axis direction and having a scale grating pitch P; and

(b) a readhead positionable to receive operable scale grating image light from the scale grating and provide an operable periodic image of the scale grating when the scale grating is illuminated by an illumination source that provides an effective illumination wavelength λ, the readhead comprising:

(i) a housing;

(ii) a set of respective optical detectors positioned within the housing to respectively receive different phases of the operable periodic image;

(iii) a first lens positioned within the housing to receive light from the scale grating, the first lens having a focal length F that defines a focal point located between the first lens and the set of respective optical detectors; and

(iv) an aperture positioned approximately at the focal length F between the first lens and the set of respective optical detectors;

wherein:

the operable periodic image has a fundamental spatial frequency corresponding to the scale grating pitch P; and

the aperture is configured with a dimension W along the measuring axis direction such that $W= F*\lambda*(n/P)$, and one of the following conditions is satisfied:

C1) the operable scale grating image light is incoherent and n is greater than 1.2 and at most 3.5, and

C2) the operable scale grating image light is coherent and n is greater than 2.0 and less than 6.0.

12. The device of Claim 11, wherein in the condition C1 n is at most 3.0.

13. The device of Claim 12, wherein P is at most 20 μm and in the condition C2 n is at most 3.5.

14. The device of Claim 13, wherein P is at least 15μm and in the conditions C1 and C2 n is at least 2.1and at most 2.7.

15. The device of Claim 13, wherein in the condition C2 n is at most 3.0.

16. The device of Claim 15, wherein P is at most 15μm and in the conditions C1 and C2 n is at most 2.5.

17. The device of Claim 16, wherein in the condition C1 n is at least 1.4.

18. The device of Claim 16, wherein P is at most 12μm and in the conditions C1 and C2 n is at most 1.8.

19. The device of Claim 18, wherein in the condition C1 n is at least 1.4.

20. The device of Claim 12, wherein in the condition C1 n is at most 2.0 and in the condition C2 n is at most 4.0.

21. The device of Claim 11, wherein the aperture has a dimension H along a direction perpendicular to the measuring axis, wherein H is at least 2 times W.

22. The device of Claim 21, wherein H is at most $(2M/(1+M_y))(R-Fo)$, where M_y= a nominal magnification of the operable periodic image along the direction of the relatively elongated dimension at a detection plane of the set of respective optical detectors, R = a lens radius perpendicular to an optical axis of the first lens and aperture, and Fo = a nominal dimension between the optical axis and an edge of the field of view at the scale grating and along the direction of the elongated dimension, when the edge of the field of view is defined by the dimensions of the light receiving elements of the readhead and the optical magnification M_y.

23. The device of Claim 11, wherein each of the respective optical detectors generates an output signal comprising a sinusoidal function of the relative displacement, and the sinusoidal function varies from an ideal sinusoidal function by at most 1/16 of the peak-to-peak variation of the sinusoidal function.

24. The device of Claim 23, wherein the sinusoidal function varies from an ideal sinusoidal function by at most 1/32 of the peak-to-peak variation of the sinusoidal function.

25. The device of Claim 11, wherein the readhead further comprises the illumination source.

26. The device of Claim 25, wherein the readhead comprises a reflective surface surrounding the aperture, the reflective surface angled to receive light from the illumination source and deflect that light through the first lens to illuminate the scale grating.

27. The device of Claim 11 in a transmissive configuration such that bright regions of the operable periodic image arise from light transmitted through the scale grating.

28. The device of Claim 11 in a reflective configuration such that bright regions of the operable periodic image arise from light reflected from the scale grating.

29. The device of Claim 28, wherein the scale grating comprises faceted reflective surfaces that are angled with respect to a nominal plane of the scale grating.

30. The device of Claim 29, wherein:

the readhead further comprises the illumination source and illuminates the scale grating along a nominal illumination angle relative to a nominal plane of the scale grating; and

the scale grating comprises a first faceted reflective surface in each period of the scale grating that is nominally angled to receive illuminating rays along the nominal illumination angle and reflect those rays along a direction nominally parallel to an optical axis of the readhead, such that brighter regions in the operable periodic image arise from the first faceted reflective surfaces.

31. The device of Claim 30, wherein the optical axis of the readhead is nominally normal to the nominal plane of the scale grating.

32. The device of Claim 11, wherein the scale grating is provided by a tape-type scale.

33. The device of Claim 11, wherein the scale grating is fixed to a generally planar member along a measuring axis direction that follows a straight line on the planar member.

34. The device of Claim 11, wherein the scale grating is fixed to a generally planar disk-like member along a measuring axis direction that follows a circular path on the disk-like member.

35. The device of Claim 11, wherein the scale grating is fixed to a generally cylindrical member along a measuring axis direction that follows a circular path around the cylindrical member.

36. The device of Claim 11, wherein the set of respective optical detectors comprises a set of phase masks included in a set of respective fiber optic receiver channels and the readhead outputs respective optical signals along the respective fiber optic receiver channels, the respective optical signals comprising a sinusoidal function of the relative displacement, and the sinusoidal function varies from an ideal sinusoidal function by at most 1/16 of the peak-to-peak variation of the sinusoidal function.

37. The device of Claim 36, wherein the readhead is a miniature fiber optic readhead constructed such that at least a portion of a length of the housing can be inserted into a bore having a dimension perpendicular to its central axis that is at least as small as 5.0 millimeters.

38. The device of Claim 11, the readhead further comprising a second lens having a focal length Fs, the second lens positioned within the housing between the aperture and the set of respective optical detectors at the focal length Fs from the aperture, to receive light from the aperture and form the operable periodic image.

39. The device of Claim 38, wherein a magnification M of the operable periodic image along the measuring axis direction is approximately M=Fs/F, and is set solely by adjusting the distances Fs and F.

40. The device of Claim 38, wherein the second lens has the same nominal optical characteristics as the first lens, Fs=F, and the first and second lenses are oriented symmetrically about the location of the aperture.

41. A device for measuring the relative displacement between two members, the device comprising:

(a) a scale grating extending along a measuring axis direction; and

(b) a readhead positionable to receive operable scale grating image light from the scale grating and provide an operable periodic image of the scale grating when the scale grating is illuminated with an effective illumination wavelength, the readhead comprising:

(i) a housing;

(ii) a lens positioned within the housing to receive light from the scale grating, the lens having a focal length F that defines a focal point on a side of the lens that faces away from the scale grating;

(iii) an aperture positioned approximately at the focal length F from the lens; and

(iv) a set of respective optical detectors positioned within the housing to respectively receive different phases of the operable periodic image, the set of respective

optical detectors positioned at a distance D from the aperture, on the side of the aperture that faces away from the scale grating;

wherein a magnification M of the operable periodic image along the measuring axis direction is approximately M=D/F, and is set solely by adjusting the distances D and F.

42. A method for operating a device for measuring the relative displacement between two members, the device comprising:

(a) a scale grating extending along a measuring axis direction and having a scale grating pitch P; and

(b) a readhead positionable to receive operable scale grating image light from the scale grating and provide an operable periodic image of the scale grating when the scale grating is illuminated with an effective illumination wavelength λ, the readhead comprising:

(i) a housing;

(ii) a set of respective optical detectors positioned within the housing to respectively receive different phases of the operable periodic image; and

(iii) a diffraction-limited imaging system comprising;

(iii-1) a first lens positioned within the housing to receive light from the scale grating, the lens having a focal length F that defines a focal point located between the lens and the set of respective optical detectors; and

(iii-2) an aperture positioned approximately at the focal length F between the lens and the set of respective optical detectors and having a dimension W along the measuring axis direction such that $W= F*\lambda*(n/P)$ and one of the following conditions is satisfied: C1) the operable scale grating image light is incoherent and n is greater than 1.2 and at most 3.5, and C2) the operable scale grating image light is coherent and n is greater than 2.0 and less than 6.0;

the method comprising:

operably positioning the readhead relative to the scale grating;

inputting the operable scale grating image light from the scale grating through at least the first lens and the aperture to provide the operable periodic image;

receiving the operable periodic image at an image receiving plane of the set of respective optical detectors; and

outputting at least two respective out-of-phase output signals derived from the received operable periodic image and the set of respective optical detectors, the output signals comprising approximately sinusoidal functions of the relative displacement.

43. The method of Claim 42, wherein each sinusoidal function varies from an ideal sinusoidal function by at most 1/16 of the peak-to-peak variation of the sinusoidal function.

44. The method of Claim 42, wherein each sinusoidal function varies from an ideal sinusoidal function by at most 1/32 of the peak-to-peak variation of the sinusoidal function.